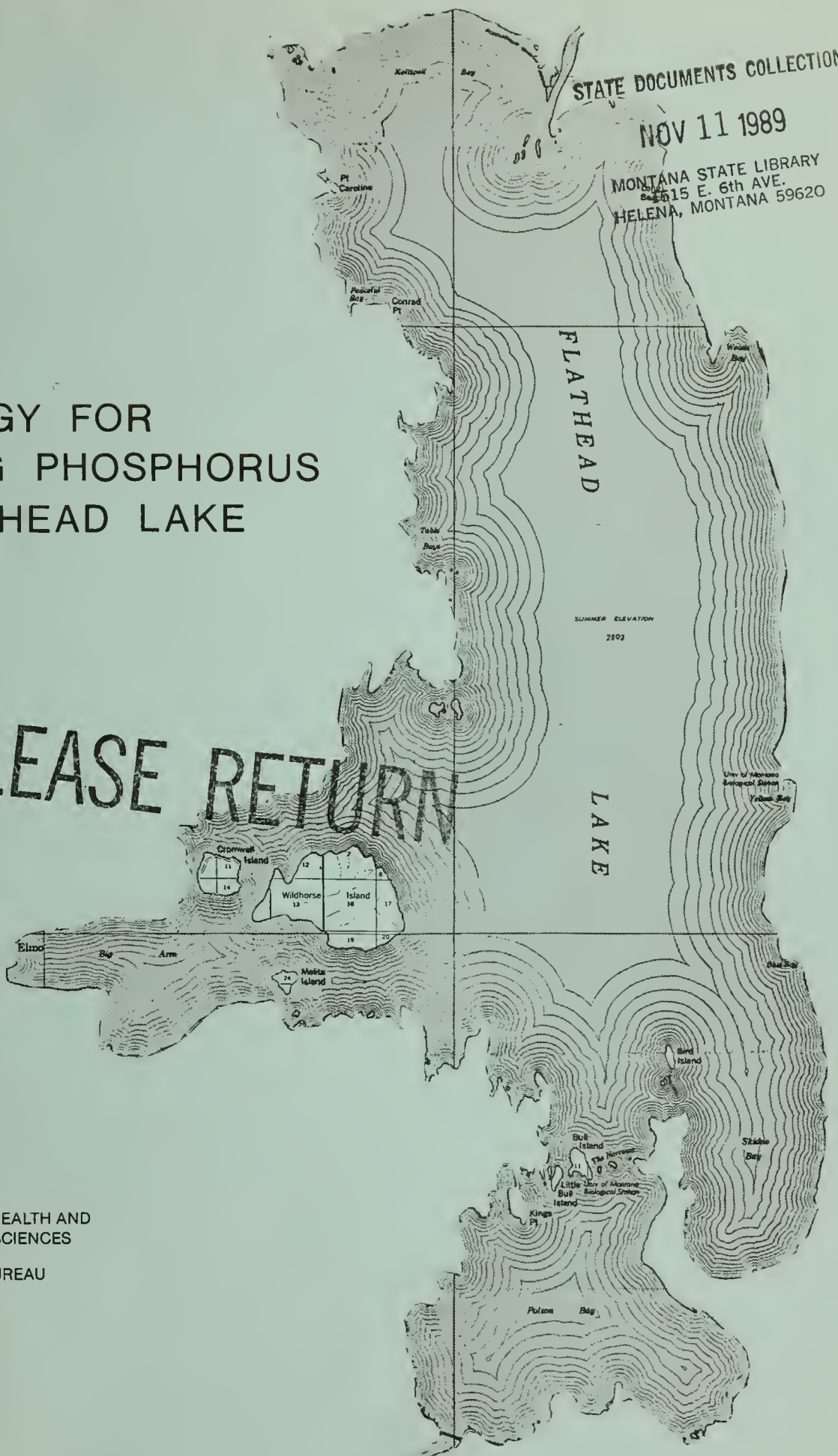
S
363.7394
H12slp
1984

STATE DOCUMENTS COLLECTION
NOV 11 1989
MONTANA STATE LIBRARY
1515 E. 6th AVE.
HELENA, MONTANA 59620

STRATEGY FOR LIMITING PHOSPHORUS IN FLATHEAD LAKE



PLEASE RETURN

DEPARTMENT OF HEALTH AND
ENVIRONMENTAL SCIENCES

WATER QUALITY BUREAU

APRIL 27, 1984

MONTANA STATE LIBRARY
S363.7394 H2sLp 1984
Strategy for limiting phosporus in Flath
3 0864 00063978 4

SUMMARY

Bodies of water, like people, age. The process of aging is unstoppable and irreversible. Flathead Lake is no exception. It is getting older and changing.

One way scientists judge how old a lake is and how fast it is aging is to measure how much algae it produces from year to year. By this yardstick, Flathead Lake is leaving youth for middle age and it is aging rapidly.

Phosphorus is the nutrient that controls the growth of algae in the lake. Besides precipitation and dust deposited directly on the lake, the main sources of phosphorus in Flathead Lake are domestic and municipal wastewater, including household detergents, and particles of soil eroded from the land. The amount of phosphorus entering Flathead Lake each year has increased because of the increase in the number of people living in the basin and in the area of land surface that has been disturbed and cleared of its protective vegetation.

To control aging is to control algae; to control algae is to control phosphorus; and to control phosphorus is to treat wastewater and control erosion.

Although the aging of Flathead Lake cannot be stopped, a concerted effort can slow the process, improve the condition and lengthen the lifespan of the lake. This report suggests some steps that government agencies, local communities and concerned people can take to reduce the amount of phosphorus entering Flathead Lake and restore the lake's youthful qualities and maintain them for a longer period of time.

PHOSPHORUS IMPACTS ON FLATHEAD LAKE

Flathead Lake, the largest natural freshwater lake in the western United States, supports a large recreational industry, as well as serving as an important local water supply.

Recently, local residents have become quite concerned about the water quality of the lake. When gauging water quality, local residents use water clarity while lake scientists (or limnologists) measure and compare nutrient levels and trophic status of the lake. In spite of the studies that were initiated near the turn of the century (Forbes, 1893), almost no quantitative data are available to permit an evaluation of the lake's trophic history and changes due to development in the basin.

The problem centers around how fast the nutrients are accumulating in Flathead Lake. This rate of accumulation is referred to as eutrophication. A gradual process, the eutrophication of a lake progresses from the oligotrophic state, through a mesotrophic phase to the eutrophic stage. Oligotrophic means "poor" in nutrients, mesotrophic means "between poor and rich" and eutrophic means "rich."

Characteristically, young lakes are oligotrophic, consequently, there is little algal production, high concentrations of dissolved oxygen and clean water. Such lakes in temperate climates are ideal for supporting sport fish, such as trout and whitefish. These waters are distinguished by a bright blue color and the ability to see the bottom at a considerable depth.

As a lake ages, moving from the oligotrophic through mesotrophic to the eutrophic stage, it accumulates nutrients, algal production increases, clarity decreases and there may be deficits of dissolved oxygen. Typically, eutrophic lakes have periods when algal growths are visible in the forms of large "blooms." During blooms, algae may accumulate on the surface and shoreline. Eutrophic lakes will generally contain more fish numbers and/or pounds than comparable oligotrophic lakes. However, this increase is usually due to an abundance of undesirable fish, such as "pan" and rough fish, and a decrease in the abundance of sport fish. Because the concentration of dissolved oxygen may reach low levels due to the decay of excessive algal growths, fish "kills" can occur.

Increases in the amount of nutrients entering a lake due to man's activities increases the rate of eutrophication. Phosphorus is generally the nutrient which controls or limits algal growth in lakes. This is true for Flathead Lake (Stanford et al., 1984).

The current trophic status, the estimated historic status, the expected status in 20 years, and the current status with various controls are presented in Figures 1 and 2. These criteria are presented in Figure 1 for the case where all phosphorus is biologically available ("bioactive")[1].

---

[1] Total phosphorus (TP) refers to all the forms of phosphorus, both organic and inorganic. Phosphorus that is biologically available (bioactive) refers to all the phosphorus, both organic and inorganic, that can be used by algae. In a natural setting, the bioactive phosphorus available to algae does not always equal TP, since the total amount of phosphorus present cannot always be used by the organisms.

FIGURE 1: PHOSPHORUS LOADING AND MEAN DEPTH/HYDRAULIC RESIDENCE TIME RELATIONSHIP AS APPLIED TO FLATHEAD LAKE UNDER SEVERAL PHOSPHORUS LOADING SCENARIOS ASSUMING TOTAL PHOSPHORUS CONTROLS PRODUCTIVITY.

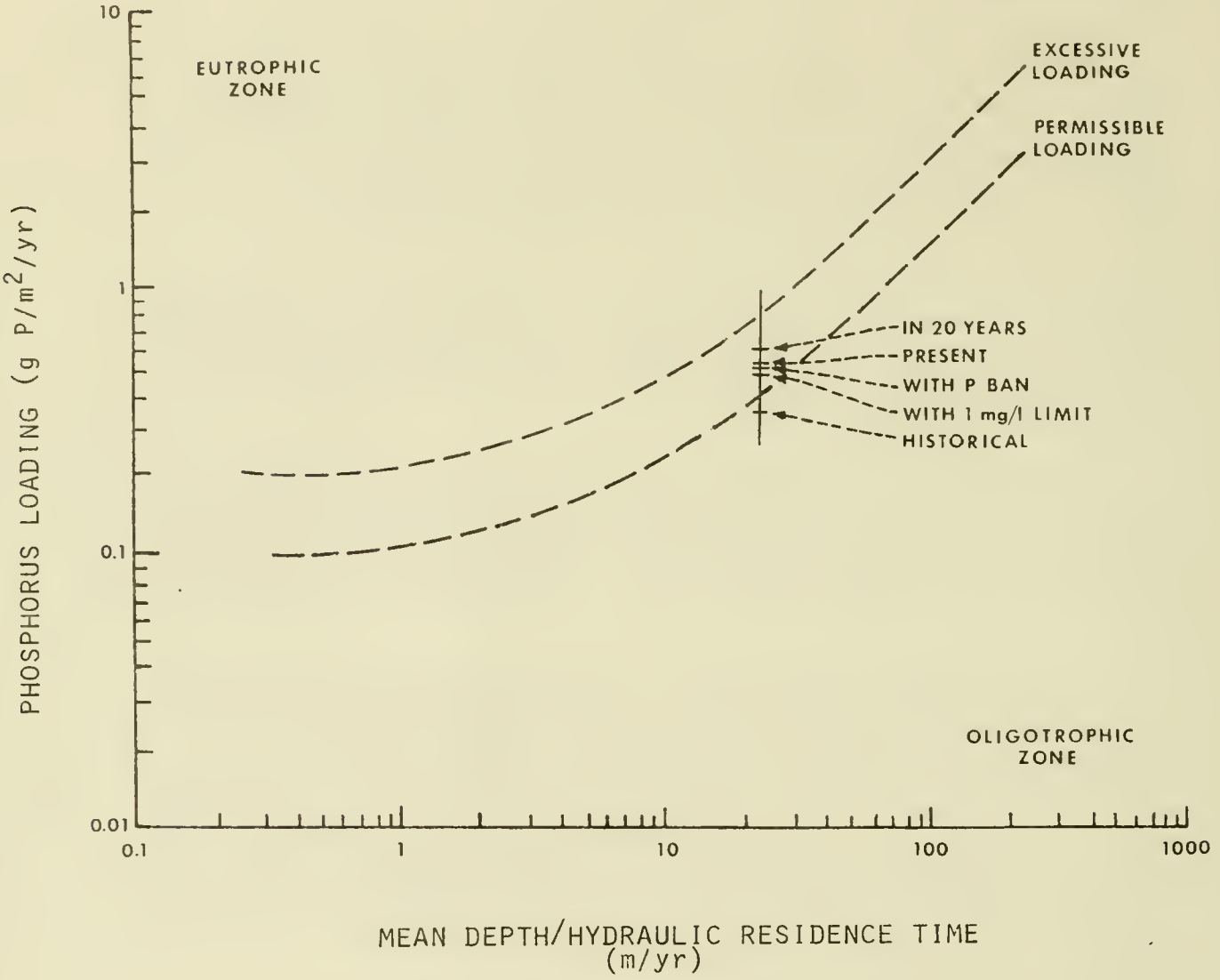
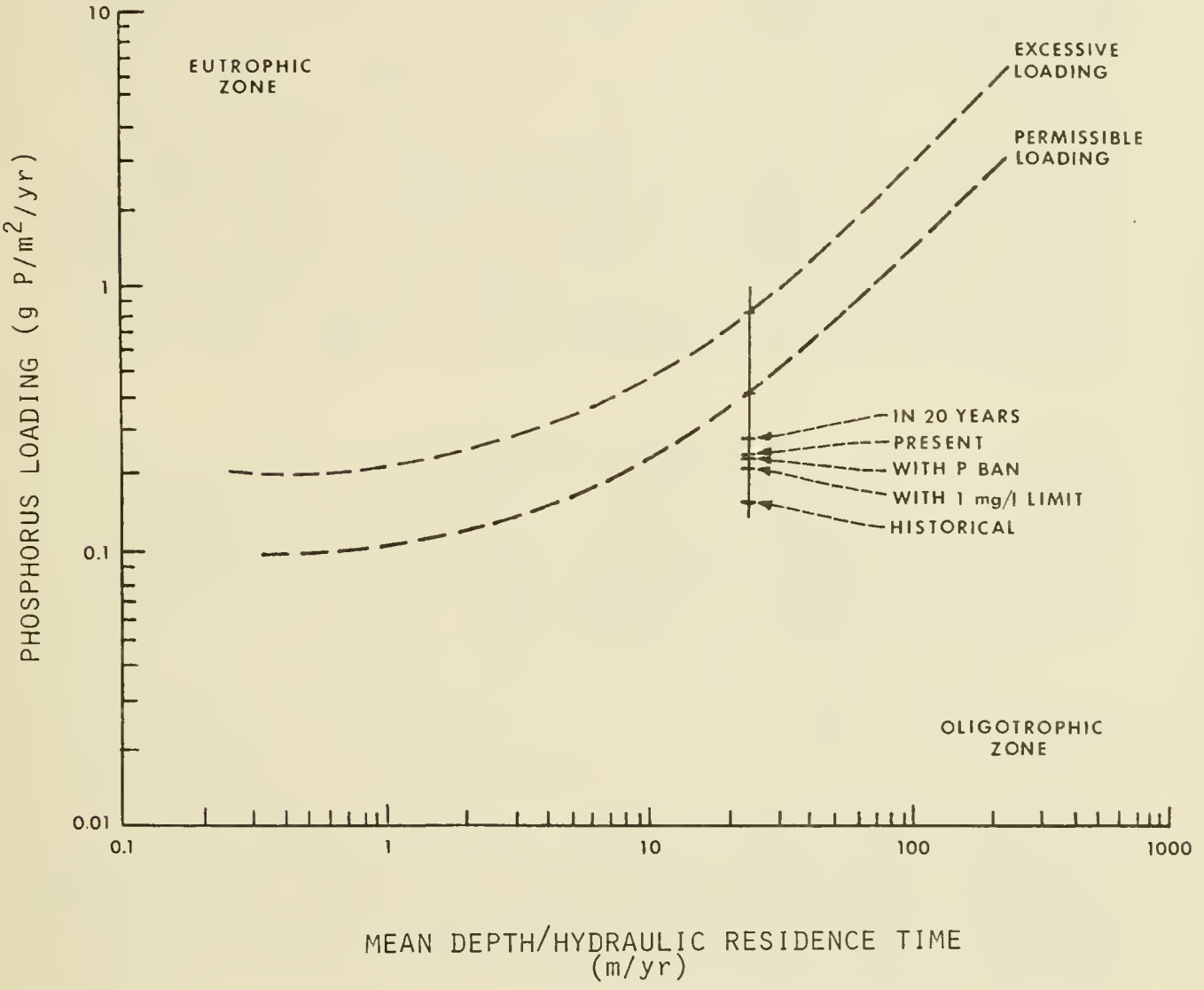


FIGURE 2: PHOSPHORUS LOADING AND MEAN DEPTH/HYDRAULIC RESIDENCE TIME RELATIONSHOP AS APPLIED TO FLATHEAD LAKE UNDER SEVERAL PHOSPHORUS LOADING SCENARIOS ASSUMING BIOACTIVE PHOSPHORUS CONTROLS PRODUCTIVITY.



Specifically the current phosphorus load is .49 g $P/m^2/yr$; it would be .475 with a limit on the use of phosphorus detergent; .45 with the implementation of a 1.0 mg/l effluent limit on point source discharges; .445 with a 10 percent reduction in nonpoint sources; and, .409 with a 10 percent reduction in nonpoint sources combined with a 1.0 mg/l effluent limit on point source discharges. With no control on phosphorus, the level would be .57 in 20 years.

Figure 2 presents the status criteria for the case where only 7 percent of the phosphorus--associated with the Flathead River's turbid spring runoff--is bioactive. The 7 percent figure was developed by Stanford et al. in 1983, but later evidence indicates the true value may be closer to 10 percent (Stanford personal communication, 1983). The current phosphorus load for Flathead Lake is .241 g $P/m^2/yr$; it would be .226 with a limit on the use of phosphorus detergents; .205 with a 1.0 mg/l limit on point source discharges; .221 with a 10 percent reduction in nonpoint sources; and, .185 with a 10 percent reduction in nonpoint sources combined with a 1.0 mg/l effluent limit on point source discharges. With no controls on phosphorus, the level would be .282 in 20 years.

Figures 1 and 2 are also based on the assumption that all the phosphorus from sources other than the Flathead River's spring runoff is bioactive. Phosphorus from identifiable point sources enters the lake at a relatively constant rate, while most of the phosphorus from nonpoint sources enters during the spring when turbidity restricts algal growth. Since the time that the phosphorus enters the lake is critical for algal production, the calculations in Figures 1 and 2 probably underestimate the importance of phosphorus from point sources.

According to Rast and Lee (1978) the permissible line designates the maximum phosphorus load that a given water body can receive and still retain its oligotrophic characteristics. From Figure 1 (total phosphorus) it appears the lake has moved from a position under the permissible line for historical phosphorus load to a position well above the permissible line under present conditions. Figure 2 (bioactive phosphorus) does not indicate a crossing of the permissible line, but does demonstrate a considerable increase in phosphorus loading has occurred. There have been deleterious changes in algal production even though the permissible line has not been crossed. The actual change in eutrophic status that has occurred is probably somewhere between those implied by Figures 1 and 2.

The modeling or theoretical changes are consistent with actual observations for Flathead Lake. Although quantitative historical data are lacking, qualitative observations document the changes. Previous investigators have consistently referred to the lake as being oligotrophic (Potter and Stanford, 1975; Gaufin et al., 1976) with a phytoplankton community dominated by many species of diatoms (Moghadam, 1969; Morgan, 1968, 1971). Concern about the effects of unnatural phosphorus loading was expressed nearly 20 years ago (Gaufin et al., 1976).

Algal blooms were recorded in mid-July 1983 (Stanford, 1983), which included large standing crops of several species of green algae not previously reported in Flathead Lake. An unidentified, small-celled (1-2 micrometers long) filamentous green algae dominated the community at the midlake site, and Botryococcus was wind-rowed on the west shore. Standing crops reached 1.5 grams/cubic meter (g/m^3) in August at midlake compared to a maximum of 0.8 g/m^3 for 1977, 1978 and 1979. Although green algae were quantitatively most abundant, a blue-green algae associated with polluted waters, Anabaena flosaquae, reached an alarming 24 percent of the total standing crop in surface samples taken in 1983.

Flathead Lake was oligotrophic until recently. It is now mesotrophic and it will be even richer in nutrients in 20 years unless phosphorus contributions are reduced. The increase in phosphorus apparently has resulted in undesirable changes, such as accelerating the growth of algae and shoreline vegetation (Stanford et al., 1983). If phosphorus loads continue to increase, the growth of algae and shoreline vegetation will become worse, and other undesirable changes, such as impacts on fish populations, may occur. Water clarity will also continue to deteriorate.

SOURCES OF PHOSPHORUS

Broadly speaking, phosphorus enters the lake from point sources and nonpoint sources. Point sources consist primarily of municipal wastewater treatment plants, although strictly speaking any direct discharge, such as a discharge from fish hatcheries or industrial processors, is a point source. These other point sources are now relatively minor in the Flathead Basin. Nonpoint sources include runoff from forested and agricultural lands, urban stormwater and seepage from individual sewage disposal systems.

Point Sources

Amounts of total phosphorus or total phosphorus loads from municipal wastewater treatment facilities upstream from Flathead Lake were estimated by J.A. Stanford et al. (1983). In Stanford's study, the 1982 total phosphorus loads from the four municipal discharges (Kalispell, Whitefish, Columbia Falls and Bigfork) were estimated to be 20.5 metric tons per year. The Water Quality Bureau (WQB), Montana Department of Health and Environmental Sciences (DHES), reviewed the 1982 and 1983 self monitoring data from the four municipalities, and estimated almost the same phosphorus load being deposited in Flathead Lake, 20.8 metric tons per year. The estimated contribution from each community varies between the two sources, however, the total load is nearly equal as shown in Table 1.

The WQB estimated not only the 1983 total phosphorus loads from point sources, but also the amount for the year 2000 (see Table 2). If growth in the Flathead River Basin occurs as suggested by the municipalities' wastewater facility plans, the total amount of phosphorus entering Flathead Lake from the four municipalities may double to 41.7 metric tons per year by the year 2000.

The WQB also estimated the year 2000 point source total phosphorus load to Flathead Lake assuming an effluent limit of 1.0 mg/l total

TABLE 1: COMPARISON OF 1982/1983 TOTAL PHOSPHORUS LOADS (TP) FROM MUNICIPAL WASTEWATER TREATMENT FACILITIES IN FLATHEAD LAKE BASIN

	WQB Estimate metric tons per year	J.A. Stanford, et al., Estimate metric tons per year
Kalispell	8.4	11.7
Whitefish	5.8	5.0
Columbia Falls	3.9	2.7
Bigfork	2.7	1.1
TOTAL	20.8	20.5

TABLE 2: TOTAL PHOSPHORUS LOADING TO FLATHEAD LAKE FROM POINT SOURCE MUNICIPALITIES.

	Year 1983			Year 2000			
		Phosphorus			Phosphorus		
Town	Flow (MGD)	mg/l	metric tons per year	Flow (MGD)	mg/l	without P removal metric tons per year	with P removal metric tons per year
Kalispell	1.30	4.7	8.4	2.88	6.0[1]	23.8	4.0
Whitefish	.70	6.0	5.8	1.2	6.0	9.9	1.7
Columbia Falls	.30	9.5	3.9	.55	7.0[2]	5.3	.8
Bigfork	.20	9.9	2.7	.38	7.0[2]	2.7	.5
TOTAL	2.50		20.8	5.01		41.7	7.0

[1]Assume increase due to reduced influence from I/I and anaerobic digestion supernatant return to plant.

[2]Upgrading the facilities to secondary treatment will reduce the concentration of total phosphorus.

phosphorus (TP) (approximately 85% removal) was established for all four communities. An effluent limit of 1.0 mg/l TP was selected as an economically and technically achievable value. The load would total 7.0 metric tons per year, which is 1/6 of the anticipated municipal phosphorus load in the year 2000 without phosphorus removal and 1/3 of the amount recorded in 1983.

Non-Point Sources

Stanford et al. (1983) estimate that about 75 percent of the total phosphorus entering Flathead Lake originates from nonpoint sources, another 15 percent from precipitation and dry fallout and the remaining 10 percent from point sources. Only a small percentage of the total phosphorus from nonpoint sources is bioactive and can be used by the algae in the lake, in contrast to the phosphorus discharged from municipal wastewater treatment plants and the phosphorus in precipitation and dry fallout, which is virtually all available for algae growth. Hence, about 55 percent of the bioactive phosphorus entering Flathead Lake is from nonpoint sources, about 25 percent from precipitation and dry fallout, and the remaining 20 percent from point sources.

Most of the phosphorus from nonpoint sources is associated with particles of silt and clay deposited in the lake each spring during snowmelt runoff. Nonpoint sources of phosphorus to Flathead Lake can thus be equated with nonpoint sources of sediment. The principal man-caused sediment sources in the basin upstream from the lake outlet can be equated with the principal land use categories and associated sediment-producing activities (Seastedt and Tibbs, 1974; Nunnallee et al., 1976):

Non-reserved Forestland	Timber Harvest Logging Roads Grazing
Wilderness and Parks	Roads and Trails
Cropland and Pasture	Irrigated Farming Dryland Farming Grazing
Urban Areas and Subdivisions	Urban Runoff Construction

Loads of sediment and phosphorus generated by the human activities listed above are superimposed over natural loads of sediment and phosphorus delivered to Flathead Lake. Natural events, like landslides and the flood of 1964, destabilize entire watersheds and continue to enhance sediment yields within the basin. Hungry Horse Dam prevents a significant fraction of nonpoint source sediment from reaching Flathead Lake. Clearcutting, both in Canada and Montana, has increased water yield and streambank erosion, notably along the North Fork of the Flathead River. These fine streambank sediments are rich in natural phosphorus. The WQB's evaluation of the proposed Sage Creek coal mine in British Columbia estimates the mine would increase the amount of bioactive phosphorus deposited in Flathead Lake by about 0.5 percent each year.

A study conducted by the University of Montana School of Forestry and the Montana Forest and Conservation Experiment Station (Bodmer and Stark, 1980) attempted to quantify the effect of land uses on nutrient levels in each of four study streams: Swift Creek, Whitefish River, Stillwater River and Spring Creek. Table 3 presents the relative contributions of phosphorus by different land types in the study area to the total load in the streams draining the area. The land areas are not representative of the Flathead Basin as a whole; forest lands are underrepresented and other land types are overrepresented compared to the entire Flathead Basin. However, the figures agree with findings elsewhere that agricultural and mixed watersheds export more phosphorus per unit land area than do forested watersheds (Uttormark et al., 1974; Reckhow et al., 1980).

Estimates of phosphorus deposition and export for the entire Flathead Basin are presented in Table 4. The figures in this table demonstrate the importance of forest land as a source of phosphorus in Flathead Lake. Potentially, forest lands would contribute about 82 percent of the nonpoint source phosphorus entering the lake, excluding direct precipitation and dry fallout. However, much of the sediment and associated phosphorus exported from alpine and forest lands at higher elevations is trapped behind Hungry Horse Dam and in Whitefish, McDonald and the many other lakes in the basin.

The average annual phosphorus export coefficient for the Flathead River drainage above Columbia Falls was calculated as 0.041 kilograms of phosphorus per hectare per year (kg P/ha/yr). This estimate was based on discharge and total phosphorus data recorded for the water years 1979 through 1982 at the U.S. Geological Survey water quality station in Columbia Falls (U.S. Geological Survey, 1979-1982).

Total phosphorus export coefficients for a large number of forested watersheds in the northern hemisphere have been assembled by Uttormark et al. (1974) and by Reckhow et al. (1980). Total phosphorus ranged from 0.01 to 0.86 kg P/ha/yr, with an average value of about 0.25 kg P/ha/yr. Rast and Lee (1978) apply an export coefficient of 0.1 kg P/ha/yr in calculating phosphorus loadings for water bodies in North America. Evidently the upper Flathead Basin is still well below average among forested watersheds in terms of phosphorus export per unit area. This may be explained by the fact that much of the drainage above Columbia Falls includes large areas of undeveloped land, such as portions of Glacier National Park and the Bob Marshall and Great Bear wilderness areas. Also, much of the phosphorus is trapped behind Hungry Horse Dam and in the many large lakes along the west side of Glacier Park.

Applying the smaller phosphorus export value of 0.041 kg P/ha/yr to the estimate of forested area in the Flathead drainage (Table 4) yields a phosphorus export value of about 70,000 kg/yr. On this basis, forest lands still contribute the largest share of phosphorus (66 percent) of all land cover types in the basin, excluding direct precipitation and dry fallout on lakes.

In summary, direct deposition and export from forest lands are the two major sources of phosphorus in Flathead Lake other than discharges from municipal wastewater treatment plants. Although the phosphorus export coefficient for the forested lands above Columbia Falls is smaller than the North American average, forested lands still account for the majority of

TABLE 3: RELATIVE CONTRIBUTIONS OF PHOSPHORUS BY DIFFERENT LAND TYPES IN THE SWIFT CREEK, WHITEFISH RIVER, SPRING CREEK, AND STILLWATER RIVER DRAINAGES TO THE TOTAL PHOSPHORUS LOAD CARRIED BY THESE STREAMS (Bodmer and Stark, 1980).

Land Type	Percent of Area Studied	Percent of Total Phosphorus Load
Forested Lands*	74.8	5.3
Agricultural Lands*	8.4	22.9
Mixed Uses**	16.6	23.6

*Greater than 85 percent of the area is dedicated to the designated use.

**Mixed urban, agricultural, and forest uses, none greater than 85 percent of the land area.

TABLE 4: ESTIMATES OF NET PHOSPHORUS EXPORT FROM MAJOR LAND COVER TYPES IN THE FLATHEAD BASIN AND DIRECT DEPOSITION ON LAKES AND RESERVOIRS.

	Area (ha)[1]			Phosphorus Export Coefficient[2] (kg/ha/yr)	Phosphorus Export (kg/yr)	%
	Flathead Co.	%	Flathead Basin			
Forest	1,235,000	93	1,708,600	0.1	170,860	63
Agriculture/ Rural	40,000	3	55,100	0.5	27,550	10
Urban	5,000	0.5	9,200	1.0	9,200	3
Lakes (Direct Precipitation and Dry Fallout)	50,000	3.5	64,300	1.0	64,300	24
Totals	1,330,000	100	1,837,200	---	271,910	100

[1]Sources: Seastedt and Tibbs, 1974; James E. Mohn, Flathead County Senior Planner, personal communication, April 6, 1984; Stanford et al., 1983; Anonymous, 1974.

[2]Source: Rast and Lee, 1978.

Note: In estimating the number of hectares (ha) in each land cover type in the Flathead Basin, it was assumed that each type accounted for the same percentage of the whole as in Flathead County. Only the area of Flathead Lake (about 50,000 ha) was included under the "Lakes" category for Flathead County. One hectare equals 2.47 acres.

the nonpoint source phosphorus entering Flathead Lake by virtue of the fact they occupy about 90 percent of the drainage area.

PHOSPHORUS CONTROL ALTERNATIVES

Point Sources

Cost estimates, based on 1984 construction figures, to achieve phosphorus removal at a discharge limit of 1.0 mg/l TP were prepared by the WQB for the four municipal discharges upstream from Flathead Lake (Kalispell, Whitefish, Columbia Falls and Bigfork). An effluent limit of 1.0 mg/l TP is relatively easy to achieve with current technology and is economically feasible. Capital improvements to reach phosphorus limits of 0.5 to 2.0 mg/l TP are basically the same. As the limit is lowered from 2.0 to 0.5 mg/l TP, operating costs increase mostly in the form of chemical costs.

General planning level construction costs were based on federal Environmental Protection Agency (EPA) construction cost guides and municipal facility plans. Phosphorus removal facilities, for purposes of estimation, include chemical treatment of wastewater, effluent filtration, and buildings to house chemical and filtration facilities.

A summary of the cost estimates for each community to achieve phosphorus removal to an effluent limit of 1.0 mg/l TP is presented in Table 5. Total 1984 project construction cost estimates for all four municipalities to reach the desired effluent limit is $2,351,400. The annual capital cost to communities based on an interest rate of 10 percent and a 20 year payment period without federal grants would total $276,240 and with federal grants, $96,100. Total annual cost (capital, operation and maintenance) to the communities for the phosphorus removal facilities to achieve 1.0 mg/l TP would total $610,500 without federal grants and $430,360 with federal money.

EPA grants for eligible projects which have applications approved before October 1, 1984, would receive 75 percent of the project costs. After that date, grants will be reduced to 55 percent due to the changes in federal legislation. For purposes of this report, it was assumed that Bigfork and Kalispell can meet the October deadline, while Whitefish and Columbia Falls cannot.

The cost to achieve phosphorus removal to 1.0 mg/l TP (about 85 percent removal) for municipal wastewater discharges for an average household or residential equivalent user would be about $2.70 per month without federal grant assistance and $1.90 with federal funding.

The discharge of phosphorus from new point sources can be and has been effectively controlled by the provisions of Montana's non-degradation rule. The use of this rule to regulate point sources does not apply to future Canadian coal development. The state is working with British Columbia provincial officials in an attempt to control any future mining related sources.

TABLE 5: SUMMARY OF COSTS FOR PHOSPHORUS REMOVAL IN FLATHEAD RIVER BASIN UPSTREAM FROM FLATHEAD LAKE

	Kalispell	Whitefish	Col. Falls	Bigfork	Total
Year 2000					
Design Flow (MGD)	2.88	1.2	.55	.38	5.01
Population	30,000	10,000	4,900	2,100	47,000
Residential Equivalent User[1]	12,000	4,000	1,960	840	18,800
Without Grants					
Total Project Cost[2]	$975,700	$758,700	$390,000	$227,000	$2,351,400
Annual Capital Cost	114,600	89,140	45,800	26,700	276,240
Annual O & M Cost	192,400	80,160	36,700	25,000	334,300
Total Annual Cost	307,000	169,300	82,500	51,700	610,500
Total Monthly Cost Per Residence or Residential Equivalent User	$2.13	$3.53	$3.51	$5.13	$2.71
With Grants[3]					
Local Share Total Project Cost	$243,900	$341,400	$175,500	$ 56,800	$ 817,600
Annual Capital Cost	28,700	40,100	20,600	6,700	96,100
Annual O & M Cost	192,400	80,160	36,700	25,000	334,300
Total Annual Cost	221,100	120,260	57,300	31,700	430,360
Total Monthly Cost Per Residence	$1.54	$2.51	$2.44	$3.14	$1.91

[1] 2.5 people per residential equivalent user
[2] 1984 dollars--total project cost for phosphorus removal to 1.0 mg/l TP
[3] Kalispell and Bigfork receive 75% grant; Whitefish and Columbia Falls receive 55% grant

Nonpoint Sources

Because of the large number, complex nature and wide distribution of nonpoint sources of phosphorus in the Flathead Basin, they will be difficult and costly to control compared to point sources. The control of nonpoint source pollution is often accomplished by applying "best management practices" (BMP's). Although they are feasible in a technical sense, such controls are usually voluntary and not always implemented because they add measurably to the cost of resource development. In a large drainage such as the Flathead, nonpoint source controls would need to be numerous and extensive in order to achieve a measurable reduction in sediment (phosphorus) loads and an improvement in water quality in Flathead Lake. Even to maintain the status quo in the face of accelerated mining and timber harvest activities will require a considerable investment of soil and water conservation measures. Only limited control can be exercised over activities in Canada that would degrade waters on the Montana side of the border. Natural events, such as floods, landslides, and deforestation could negate efforts to control erosion and stabilize streambanks. Effective implementation of nonpoint source controls often requires an unprecedented degree of cooperation and coordination among government agencies at different levels of jurisdiction, and between adjacent landowners, whether they be private or public.

The former staff and Board of the Flathead Drainage 208 Project developed and adopted a large number of recommendations for controlling nonpoint source pollution (Flathead Drainage 208 Project, undated). For the most part, these recommendations call for voluntary cooperation and coordination among resource managers, compliance with existing laws and regulations and application of BMP's. A number of local, state, and federal agencies were assigned responsibility for implementing the Board's recommendations. If the implementation plan fails to produce desired water quality effects, then regulation, in the form of a county sediment control ordinance, is recommended. Also recommended is a statewide forest practices act.

The Flathead 208 Board and staff were to play significant roles in implementing the water quality management plan. An executive board would have set policy and met with staff monthly "to receive updates on progress and give direction". The staff would have been responsible for plan oversight and implementation of policy, coordination with implementing agencies, continuing education, and public involvement. Unfortunately, the Flathead 208 Board is inactive and its staff no longer exists.

Without an active nonpoint source water quality management agency in the Flathead, the responsibility for implementing BMP's will fall directly on individual landowners and on public land management agencies.

County Conservation Districts will continue to oversee the identification and correction of agricultural water quality problems with the Soil Conservation Service and the Agricultural Stabilization and Conservation Service providing technical assistance and financial incentives, respectively. The Cooperative Extension Service and Agriculture Research Centers at Corvallis and Creston are responsible under the plan for disseminating information on BMP's "to mitigate deleterious effects of irrigation return flows."

On forested watersheds, the plan calls for 1) cooperative management among landowners within a drainage in order to minimize stream channel instability, and 2) a cooperative water quality monitoring program. A yet to be implemented program of tax incentives, education and low interest loans was recommended to encourage private forestland owners to use BMP's. The Division of Forestry, Department of State Lands, was charged with applying BMP's on state lands, preparing environmental assessments on proposed timber sales (under the Montana Environmental Policy Act) and allowing on-site visits and project overviews by the water quality management agency. The Division of Forestry has since developed and begun implementing a comprehensive water quality training program for loggers and forestland managers.

The U.S. Forest Service was designated as the nonpoint source water quality management agency on National Forest lands, both by the Flathead and Statewide 208 water quality management plans. The Flathead National Forest is a major influence in the Flathead drainage. More than half of the land area in the Flathead Basin above Polson is managed by the U.S. Forest Service. Of this area, about 40 percent is non-reserved commercial forest land, which is 21 percent of the total land area in the basin. Under current forest management plans, there will be increases in sediment (and phosphorus) yield on 45 percent of the nonwilderness watersheds on the Flathead National Forest over the next ten years (Flathead National Forest, 1983).

There are a number of laws, regulations and executive orders which require that federal agencies, such as the Forest Service, comply with federal, state, and local water pollution control requirements. Among them are Sections 313 and 401 of the Clear Water Act, Executive Orders 12088 (Federal Compliance with Pollution Standards) and 12372 (Intergovernmental Review of Federal Programs), NEPA, and Federal Regulations, particularly 36 CFR 219.23, which mandates that Forest Management Plans provide for compliance with the Clean Water Act. However, according to Gerhart Nelson, former Director of Range and Watershed for Region One, "Water quality monitoring stations and watershed improvement projects have been reduced on most forests and future funding indicates a continued low level in these areas" (personal communication, December 12, 1983).

The performance of the Flathead National Forest in protecting water quality might be improved in several ways. The EPA might be petitioned to require the Forest Service to adequately fund water quality monitoring and watershed improvement projects on the Flathead Forest. The State of Montana might consider establishing a "Silvicultural Task Force" similar to the one established in Idaho (Idaho Department of Health and Welfare, 1983). The purpose of the Idaho Task Force is to determine whether existing BMP's, as they are being implemented on forested lands in the state, are giving adequate protection to water quality. Another option would be for the State Water Quality Bureau to assume a larger role in reviewing timber sales and other activities on national forest lands.

In terms of control, individual septic tank and drainfield disposal systems need to be considered separately from other nonpoint sources. A drainfield disposal system located in a loam or clay of adequate depth will retain phosphorus for an extended period of time. Material such as gravel and sand will have a low capacity for retention of phosphorus. A limit on

phosphorus content in detergents appears to be one means of partially controlling phosphorus entering these systems. Using low--or phosphorus free--detergents would probably reduce the phosphorus contribution to the systems by about 35 percent (Lee, 1976). Septic tank drainfields may significantly impact small lakes so controlling phosphorus by limiting detergents may have a strong influence on water quality. No estimates of the total phosphorus contributed to lakes from subsurface disposal systems are available, but whatever the amount, it's almost certain to increase. In the future, greater importance needs to be given to the flow of phosphorus from septic tank disposal fields to surface water, with emphasis on determining the amount of phosphorus retained by various soils.

RECOMMENDATIONS

The following are recommendations of steps government agencies, local communities and concerned people can take to reduce the amount of phosphorus entering Flathead Lake:

1. Immediately impose a 1.0 mg/l effluent limit for phosphorus on all MPDES permits for point sources in the Flathead Lake drainage basin. Permittees would be required to submit a compliance schedule under the provisions of the MPDES permit.

2. Expand the monitoring and evaluation program to 1) refine the phosphorus budget for the Flathead Lake drainage basin, 2) monitor the effects of the management plan, and 3) determine the percentage of phosphorus from forests which is bioactive and seek a reduction in that amount.

3. Recommend legislation to require the sale of only low or phosphorus free detergents (except dishwashing detergent) in the area.

4. Implement a local nonpoint source program to control phosphorus from forest activities, agricultural practices, land development and urban runoff. Review forest plans and forest activities, especially the construction of roads and timber sales from the national, state and private forests to make sure Best Management Practices are used and desired water quality results achieved. Request the Forest Service develop a forestwide sediment plan and develop the monitoring to insure compliance with the plan.

5. For subdivision review and approval, require developers to have evaluations for phosphorus adsorption in soils where drainfields will be sited if the systems are within 1/2 mile of any flowing water. A 50-year phosphorus adsorption life would be assumed. The WQB will consider promulgating a lakeshore development rule to control nutrients from wastewater disposal from such developments.

6. Develop an evaluation and management plan for non-sewered communities in the Flathead Lake drainage basin.

REFERENCES

1. Anonymous, 1974, Comprehensive Development Plan: Kalispell Planning Area. Kalispell City-County Planning Board.

2. Bodmer, S. and N. Stark. 1980. Final Report on Studies of Non-Point Source Pollution in the Upper Flathead Drainage. University of Montana School of Forestry, Missoula.

3. EPA, "Process Design Manual for Phosphorus Removal," April 1976, EPA 625/1-76-001a.

4. EPA, "Construction Costs for Municipal Wastewater Treatment Plants: 1973-1977," January 1978, EPA 430/9-77-013.

5. Flathead Drainage 208 Project. Undated. Legal, Institutional and Implementation, Executive Summary. Flathead Drainage 208 Project, Kalispell.

6. Flathead National Forest, 1983. Proposed Forest Plan. Forest Service, U.S. Department of Agriculture.

7. Forbes, S.A. 1893. A preliminary report on the invertebrate fauna of Yellowstone National Park and the Flathead Region of Montana. Bull. U.S. Fish. Comm. 11:207-256.

8. Gaufin, A.R., G.W. Prescott and J.F. Tibbs. 1976. Limnological studies of Flathead Lake, Montana: A status report. EPA-600/3-76-039. 91 pp.

9. Idaho Department of Health and Welfare. 1983. Silvicultural Nonpoint Source: Problem Assessment and Management Strategy. State of Idaho 205(j) Work Plan, Phase I.

10. Lee, G.F. 1976. Review of the Potential Water Quality Benefits from a Phosphate Built Detergent Ban in the State of Michigan. Testimony Presented at Michigan Department of Natural Resources Hearing on a Detergent Phosphate Ban, December 8, 1976, Lansing, Michigan. 51 pp.

11. Moghadam, F. 1969. Ecological and Systematic Study of Plankton Diatom Communities in Flathead Lake, Montana. Ph.D. Dissertation. Univ. Utah, Salt Lake City. 206 pp.

12. Morgan, G.R. 1968. Phytoplankton Productivity of the Eastshore Area of Flathead Lake, Montana. M.S. Thesis. Univ. Utah, Salt Lake City. 146 pp.

13. Morgan, G.R. 1971. Phytoplankton Productivity Versus Dissolved Nutrient Levels at Flathead Lake, Montana. Ph.D. Dissertation. Univ. Utah, Salt Lake City. 211 pp.

14. Nunnallee, D., M. K. Botz, and D.G. Willems. 1976. Water Quality Inventory and Management Plan, Flathead Drianage Basin, Montana. Montana Department of Health and Environmental Sciences, Helena.

15. Potter, D.S. and J.A. Stanford. 1975. Influences on the Plankton Communities of Oligotrophic Flathead Lake. Verh. Internat. verein. Limnol. 19:1790-1797.

16. Rast, Walter and G. Fred Lee. 1978. Summary Analysis of the North American (U.S. Portion) OECD Eutrophication Project: Nutrient Loading--Lake Response Relationships and Trophic State Indices. EPA-600/3-78-008.

17. Reckhow, K.H., M.N. Beaulac, and J.T. Simpson. 1980. Modeling Phosphorus Loading and Lake Response Under Uncertainty: A Manual and Compilation of Export Coefficients. EPA-440/5-80-011.

18. Seastedt, T.R. and J.F. Tibbs. 1974. Land Use and Water Quality in the Flathead Drainage. University of Montana Biological Station, Bigfork.

19. Stanford, J.A., T.J. Stuart, and B.K. Ellis. 1983. Limnology of Flathead Lake: Final Report. University of Montana Biological Station, Bigfork.

20. U.S. Geological Survey. 1979-1982. Water Resources Data for Montana. Water Data Reports MT-79, MT-80-2, MT-81-2, MT-82-2. Water Resources Division, Helena.

21. Uttormark, P.D., J.D. Chapin, and K.M. Green. 1974. Estimating Nutrient Loadings of Lakes from Non-Point Sources. EPA-660/3-74-020.